ARTERIAL LIGATION AS A PROPHYLACTIC MEASURE AFTER SUDDEN, COMPLETE AND PERMANENT OCCLUSION OF THE CHIEF VEIN AT THE ROOT OF AN EXTREMITY.[1]

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THIS subject depends for its interest and importance on these two questions:

1. When the chief vein of an extremity has been suddenly, completely and permanently occluded at its root, are the collateral venous bloodpaths always sufficiently ample to admit such a flow of blood through them that permanent circulatory and nutritive disturbances will not supervene?

2. If, in any appreciable proportion of cases, permanent circulatory and nutritive disturbances are likely to supervene upon such venous occlusion, what prophylactic effect, if any, would be exerted by the diminution of the force and volume of the arterial blood-supply of the limb.

Each of the modifying conditions which have been specified in connection with the occlusion of the vein are of importance. It must be *sudden*, for the tendency of collateral venous branchlets to readily and rapidly enlarge *pari passu* with any encroachment upon a main venous channel is such that if such encroachment is gradual in its progress, by the time it has become complete, a very considerable enlargement of the collateral blood-paths will have been accomplished, with a corresponding diminution of any danger of circulatory embarassment as a consequence.

In the consideration, therefore, of any clinical observations

[1] Read before the New York Surgical Society, Oct. 27, 1885.

which may seem to have a bearing upon the questions raised, those cases cannot be considered as having much weight, in which a pre-existing tumor has for some time pressed upon or possibly enveloped the vessel previous to its final complete and permanent occlusion.

The occlusion must be *complete* in order to supply the conditions requisite to produce sufficient embarassment to the return circulation to awaken solicitude as to its ultimate consequences, while upon the *permanence* of the occlusion will depend the importance of an early resort to any measure that may possibly be prophylactic against consequent disability, the permanence of which could alone make their prevention a matter of anxious care.

After this preface, I propose to take up the first question suggested:

Are the collateral venous blood-paths always sufficiently ample to admit such a flow of blood through them, in case the chief vein of the extremity has been suddenly, completely and permanently occluded, that serious permanent circulatory and nutritive disturbances will not supervene?

As bearing upon the reply to this, I desire to first call attention to certain

ANATOMICAL CONSIDERATIONS.

Sappey, in his Treatise on Descriptive Anatomy,[1] states that "copious collateral communications exist between the large vein trunks of the neck and at the root of the upper limb: channels always open, always adequate, and instantly responsive to calls upon them." He also adds: "If one of the great veins at the root of the neck is opened, the surgeon may ligate it without fear of interrupting the current of the blood."

This opinion, however, seems to be based upon a very limited number of experiments. If it was absolutely correct, there would be no occasion to further include the upper extremity in the consideration of the question proposed.

As to the lower extremity also, the statement has been made by Nicaise,[2] who based his statement, however, on a

[1] Sappey, Traite d'anat. descript, 1869, t. ii, p. 694.

[2] Nicaise, Des plaies et de la ligature des veines. Thèse, 1872, p. 113.

single experiment in addition to previous experiments by Sappey, that "after ligature of the femoral vein at the root of the limb, the return circulation is abundantly assured; although at the same time these experiments also show," he says, "that the anastomotic communications between the lower limb and the trunk are less free than those of the upper limb." With this conclusion similar experiments by Richet[1] and Verneuil[2] coincide. Braune[3] (Leipzig), however, has claimed, as the result of anatomical, experimental and literary investigations, that usually the femoral vein has no collateral branches to conduct blood from the lower extremity to the abdominal cavity in case of its occlusion. In his experiments he failed, with an injection pressure of 20 mm. Hg., to drive fluid from the peripheral branches of the femoral vein into the pelvic veins after ligation of the main trunk, in normal young subjects. He was more successful, however, on increasing the pressure.

The more recent and numerous experiments of Braun[4] (Heidelberg) give more exact and reliable data on this question of the blood-paths collateral to the femoral vein. Forty experiments were made by this observer to test the readiness of the flow of fluids from the peripheral veins of the lower limb into those of the pelvis, after ligation of the femoral at Poupart's ligament. In one the injection passed into the pelvic veins with the greatest readiness, at a scarcely appreciable pressure, equalling at the outside not more than 10 mm. Hg., thus demonstrating already existing collateral passages quite adequate to perform the function of the femoral vein itself. This was readily explained by the fact that there was present in this cadaver, on the side operated upon, a long existing glandular inguinal tumor, the gradually increasing intermittent pressure of which upon the femoral vein had occasioned a dilatation of the collaterals. In seven others a slightly higher pressure, ranging from 10 to 20 mm. Hg., sufficed to drive con-

[1] Richet, Traité pratique d'anatomie medico-chirurgicale. 2d edit. Paris. 1860. P. 161.

[2] Verneuil. Bull. de la soc. de chirurgie. 1855-56. T. VI. P. 217.

[3] Braune. Die oberschenkel Vene des Menschen. Leipzig, 1871. S. 20.

[4] Braun. Die Unterbindung der Schenkelvene am Poupartschen Bande. *Archiv. f. klin. Chirurg.* 1882. Bd. XXVIII. Hft. 3. P. 610.

siderable fluid into the pelvic veins, the obturator and ischiatic veins being the most common channels, but in some cases the median sacral, the circumflex iliac and the lumbar veins shared in the current.

In eight other instances a pressure of from 50 to 70 mm. was needed. In still other eight, from 70 to 120 mm. were required. In yet another group of eight, the pressure had to be raised to heights ranging from 120 to 150 mm. before success was secured. Of the remaining eight, in two cases a still further increase of the pressure to from 150 to 170 mm. finally caused the injection to penetrate, but in the other six, occurring in four different individuals, absolutely no communication between the femoral vein and the pelvic veins could be established, notwithstanding a pressure of 200, and in some cases 300 mm. Hg. was kept up for an hour.

Review of these results, obtained by Braun, shows that in one-fifth of the total number of experiments an injection pressure not exceeding the normal pressure of the capillary blood-current (20 mm. Hg., von Kries), sufficed to return fluid with considerable freedom into the veins of the trunk, notwithstanding the occlusion of the femoral. In these cases it may be accepted that no circulatory disturbance would have been manifested had sudden occlusion of the vein taken place during life. In the next one-fifth, in which a pressure double and treble the normal capillary was required, it may reasonably be allowed that in the living subject this extra force would have been so far supplied by the natural accessories to the venous current, muscular pressure, aspiration and, possibly, gravity, that any marked or prolonged venous engorgement or capillary embarrassment would have been escaped, as in the first group of cases.

In the third and fourth groups, however, being two-fifths of the whole number, the high pressure required was such as would certainly have entailed marked circulatory disturbances in case of sudden occlusion of the vein during life. In the last group of cases, being likewise one-fifth of the entire number, in the two instances in which any permeability was secured, it was only by a force in excess of the maximum normal arterial pressure in man (150 mm. Hg.), while in the greater number a

very much higher pressure failed absolutely. In these cases there was no possibility of the return of blood from the limb through any pre-existing collateral channels. Gangrene of the limb would have been inevitable, unless in some way the amount of blood pouring into the limb could be diminished, during the gradual opening up of new channels.

A similar careful and sufficiently extended series of experiments upon the axillary and subclavian veins is very desirable to have made. The few experiments which have been above referred to, as made by different French observers, are by no means sufficient in number to warrant any general conclusion.

I pass on, next, to present certain

CLINICAL CONSIDERATIONS.

With regard to the effect upon the circulation and nutrition of the arm which has followed sudden occlusion of the axillary vein high up, or of the subclavian, I have not attempted to compile any statistics, nor do I know of any attempt to collate the results, as far as the after nutrition of the arm is concerned, in any very large number of instances out of the many in which ligature of the axillary vein has been done in the course of operations for extirpating tumors from the axilla. In by far the great majority of such cases it must be that no serious circulatory embarrassment has been experienced, a freedom that would naturally have been expected in view of the usually abundant collateral channels. But that complicating conditions may produce a different result, the following case in my own experience demonstrates, a case which first attracted my attention to the possible results of venous occlusion, and the question of how to obviate them.

CASE I. In January, 1881, in the course of an operation for removal of carcinomatous axillary glands, being a recidive at the end of two years and nine months after the primary removal of the breast, it was necessary to sever the subscapular vein close to its entrance into the axillary. This was done, and the axillary vein itself was then tied by ligatures placed one above and one below the opening in its lateral wall thus made. The patient made a good recovery, and survived the operation for five and a half years. Very shortly, however, after the vein ligature was done, an œdema of the forearm and lower part of

the arm began to develop. This was accompanied with much of aching, aggravated in moist and changeable states of the weather; the functional power of the limb also remained permanently impaired. This condition persisted without amendment during the remaining years of her life, and became much aggravated during the days of general prostration immediately preceding her death.

In this case, in addition to the ligature of the axillary, there was simultaneous ligature of the subscapular branch as well, and also of other branches of less importance that were divided in the course of the process of clearing out the axilla. This must have diminished considerably the number of the collateral channels. But, practically, inasmuch as it is in just such cases that ligature of the main vein is most likely to be also required, this case is fairly illustrative of the conditions that requre to be taken into consideration in connection with the occlusion of the main vein at the root of the upper extremity. It is obvious that, whatever may be the adequacy of the provisions for the collateral venous circulation, if simply the main trunk is occluded near its root, the case may be quite otherwise when more or less of the collateral branches have likewise become simultaneously occluded. In further illustration of this I cite the following case:

CASE II. In April, 1885, I had occasion to remove an egg-sized carcinomatous glandular tumor at the root of the neck, in the right subclavian triangle. This was the proximal portion of a recurrent growth which likewise involved the glands of the axilla, and the cicatrix left by the removal of the right breast for carcinoma two and a half years previously. The excision of the cicatrix with the tissue adjacent that was infiltrated, and the cleaning of the axilla were accomplished without accident other than the necessary severing of certain of the lesser veins of the axilla. The growth above the clavicle was next attacked. By the preliminary incisions for uncovering it the external jugular vein and the transversalis colli and suprascapular vessels were divided. The growth was deeply fixed behind the clavicle, and the infiltration of the circumglandular connective tissue was such as to negative easy enucleation. While traction was being made to lift it from its bed, after the outer portion had been freed, a sudden copious venous hæmorrhage occurred from beneath and to the inner side of the growth. While this was controlled by properly directed

pressure, the final removal of the tumor was accomplished. Examination now revealed that a rent had occurred in both the internal jugular and the subclavian veins, the inmost point of the growth having been embraced by these veins as they converge. Ligatures above and below the points torn were applied to each vein. I had now to deal with an occlusion not only of the internal jugular and of the subclavian within an inch of their junction, but also of the external jugular, and the transverse cervical and suprascapular veins, and of numerous smaller axillary branches. It was extremely improbable that the minute collateral communications that existed could enlarge with sufficient rapidity to return any considerable proportion of the blood which was being driven into the extremity through the axillary artery; already the limb was becoming blue and swollen, and the veins which were exposed in the axillary and cervical wounds were turgid with blood, as if under great pressure. The immediate danger was evidently from the continuous forcible distension of the extremity with arterial blood. To meet this supreme indication I at once placed a ligature on the axillary artery in its upper part. The limb was then bandaged with a roller bandage and proper dressings were applied at the seat of operation. The after history of the operation wounds was uneventful. Union by first intention throughout the very extensive wound-tract was secured, except at two points in the neck, where a slight suppuration took place about some of the ligatures.

Twenty-four hours after the operation the patient had experienced no pain in the head or elsewhere. The face was somewhat flushed, especially on the side of the ligated internal jugular. There was no swelling nor lividity of the fingers of the hand of the operated extremity, which was normally warm. The patient said, however, that the hand felt as if its veins were full.

During the second week a considerable œdema of the forearm manifested itself. Bandages and rubbing were employed to dissipate it, but it persisted without much change for about three weeks. It then rapidly diminished, so that, at the end of eight weeks, it had entirely disappeared. Meanwhile the arm had regained much of its functional power, so that the patient was able to perform ordinary domestic work. Since this time her general strength and well being have continued to improve. The arm is well nourished, and, though there is no apparent œdema, it seems somewhat more plump than its fellow. The radial pulse is still imperceptible. There are as yet no signs of recurrence of cancerous disease.

Such a case as this illustrates the statement that the question as to the adequacy of collateral channels when the main

vein at the root of an extremity is suddenly occluded, as it is likely to confront the surgeon, may be a different one from the simple experiment of the anatomist, when the latter isolates and ligates the axillary or subclavian vein alone, and then proceeds to throw in his injection. The two clinical observations which I have just detailed justify the surgeon in the apprehension that permanent circulatory and nutritive disturbances of a serious character may ensue, when, in the course of operations in the axilla or at the root of the neck, in addition to the division of a considerable number of lesser collateral branches, the main vein is also completely occluded. In the second observation it is true that the operator did not delay for the full development of the circulatory and nutritive disturbances which he had reason to apprehend would follow the extensive vein ligatures which had been done, but proceeded at once to employ the only resource in his power for the diminution of the force and quantity of the inflowing stream of blood. Reference to the after-history will show, however, a train of circumstances even more instructive than would have been the occurrence of a general gangrene of the limb from venous strangulation. It is apparent that production of free collateral inlets for the arterial supply was more speedy than the development of the corresponding venous outlets, whence the œdema that showed itself during the second week and its persistence for some weeks, until the slowly enlarging venous channels had become adequate, when it fully and finally disappeared.

With regard to the effect upon the circulation and nutrition of the lower extremity produced by occlusion of the femoral vein at the root of the extremity, the researches of Braun[1] have placed at our disposal a sufficient number of clinical observations to admit of deductions of practical value.

Of the thirty-seven cases which Braun has collated, there are eighteen in which ligature of the femoral vein alone, at the level of Poupart's ligament, was practiced. Of these, thirteen cases occurred as the result of wounds inflicted in the course of operations for the removal of inguinal tumors.

[1] H. Braun. Die Unterbindung der Schenkelvene am Poupartschen Bande. *Archiv. f. klin. Chirg.* B. XXVIII. Hft. 3. S. 610.

In none of these tumor-extirpation cases did gangrene ensue. In six of them the circulatory disturbance was either very slight and transient or was absent altogether. In five others, though there was at first considerable cyanosis of the limb, it soon disappeared, leaving the limb entirely normal, or with but a slight œdema.

Two cases are recorded simply as having ended fatally, one by pyæmia, the other by inanition, without statement as to circulatory disturbances. Four deaths occurred among the other cases also from such causes as secondary hæmorrhage, pyæmia and pulmonary œdema.

These results corroborate the statements made in the earlier part of this paper as to the effect upon the development of collateral venous channels exerted by the pressure of a tumor in the groin upon the main trunk. The difference in this respect between an inguinal tumor and an axillary tumor is manifest. In the latter the loose tissues of the axilla and the position of the tumor on a plane below that of the vein favors the considerable development of the growth without subjecting the axillary vein to pressure. Not so in the groin, where the denser tissues, the force of gravity and the alternating states of tension and relaxation occurring in the flexion and extension of the thigh will very early cause a tumor to interfere with the free passage of blood through the underlying vein.

Five cases remain in which, as the result of acute injuries, high ligation of the femoral vein alone was done.[1]

The difference between the results precipitated in these acute cases, and those in which pre-existing inguinal tumors had been present, is remarkable. In one only of the five was there recovery without disturbance. One died from septicæmia three days after the ligation, but without the appearance

[1] I include in this class one case (that of Busch, 1870—being No. 32 of Braun's collection) in which the external iliac artery had been ligated forty days previously, and in which, after that period of time, in the attempt to control a secondary hæmorrhage, the femoral vein was wounded and tied. The reason for this is that so long a time had elapsed since the primary arterial ligation, that a sufficient arterial collateral circulation had been established to restore the condition of the arterial supply of the limb to nearly its original fullness. The conditions were thus entirely different from those which would have been present had simultaneous ligation of the vessels been done originally.

of gangrene—whether any less profound circulatory disturbance took place or not is not recorded; in one the limb became œdematous, with death by pyæmia; in the remaining two fatal gangrene rapidly supervened.

In addition to these cases I will here place on record a new observation, communicated to me by Dr. Wm. Browning, of Brooklyn, since it is closely allied to this class of acute cases.

CASE III. In 1881, in the course of an operation for the extirpation of a suppurating bubo in a young man of about 22 years of age, the internal saphenous vein was wounded, and for the control of the hæmorrhage a ligature was placed upon it close to the main femoral trunk. The patient recovered without special untoward symptom until he began to be up, when an œdema of the leg developed, which, after long continuance in the upright position, would become so great as to distend the whole limb up to the hip. During the night the swelling would largely disappear. At the expiration of about six months, when last seen, the tendency to œdema was still so great that he was unfitted for any work, and he begged for the removal of the limb.

Whatever the character of the obstruction to the venous return may have been in this case, it was sufficient to positively demonstrate the insufficiency of the collateral channels at the root of the limb.

The considerations, anatomical and clinical, which have now been presented, seem to me to be sufficient to justify the surgeon in the apprehension of serious circulatory and nutritive disturbances after sudden and complete occlusion of the root vein of an extremity; of the upper extremity, when the occlusion of the main vein is accompanied also by the simultaneous occlusion of any considerable number of the lesser and collateral venous channels; of the lower extremity, when the occlusion is sudden, and has not been preceded by any conditions which might have occasioned a preliminary enlargement of collateral channels, or the development of new ones.

I proceed now to the consideration of the second question propounded, viz.: *What prophylactic effect, if any, would be exerted by the diminution of the force and volume of the arterial blood supply of the implicated limb?*

The celebrity of two cases where ligature of the femoral

vein, consequent upon acute injury sustained, had been followed by speedy and fatal gangrene of the leg, and the wide diffusion of the account of a case in which an obstinately recurring hæmorrhage from wounds of the femoral vein and many collateral branches had been at once controlled by ligature of the femoral artery, with uninterrupted recovery thereafter, has served to give the procedure of simultaneous arterial ligation a status as an authorized procedure in cases of wound of the femoral vein. The cases referred to are the well-known cases of Roux and Linhart and of Langenbeck. Following this trend of surgical opinion, Lidell, in 1883, in his article on "Injuries of the Blood Vessels," in the International Encyclopædia of Surgery, vol. iii., p. 213, says: "When hæmorrhage from the common femoral vein makes deligation of that vessel necessary in order to stop the bleeding, the common femoral artery should also be ligatured in most cases, in order to equalize the circulation."

But Braun had already, in the article of which so much use has been made in this paper, protested against this procedure as "one which appeared to him to be dangerous to the patient, and neither sufficiently warranted by clinical experience nor by anatomical investigation or experiment on the cadaver."

Fortunately the industry of this observer has furnished to us both the results of extended experiments on the cadaver and of a full compilation of recorded clinical experience. This it is possible for any one to analyze and make the basis of his own conclusions.

Pursuing our own analysis of these cases, we take up those in which arterial ligation has been performed, either as a remedy for wound of the femoral vein, or in consequence of a simultaneous arterial wound, and compare the results with those in which the vein alone was ligated.

Eleven cases are reported in which such arterial ligation was done for the relief of wounds inflicted in operations for the extirpation of inguinal tumors. In two of these the artery alone was tied; the first is the case of Langenbeck, already referred to, which proceeded to an uninterrupted cure; the second was one of Kuester's, where the wound in the vein had

been temporarily secured by hæmostatic forceps; the removal of these after twenty-four hours having been followed by renewed bleeding, K. proceeded to tie the femoral artery. This stopped the bleeding; but was followed by a rapidly progressive, fatal gangrene. Of the nine cases in which both the vein and the artery were ligated, there were five cases of gangrene, one only recovering after amputation. Of the four cases in which no gangrene appeared, two died from pyæmia and one from secondary hæmorrhage, leaving but one perfect recovery out of the entire class. This is in marked contrast with the results obtained in the same class of cases from simple ligature of the vein, and abundantly justifies the opinion that *in this class of cases* ligation of the common femoral artery is dangerous to the patient and unwarranted by clinical experience.

When we turn to the class of acute injuries a somewhat different result is found. Here are seven cases; in two of these the artery alone was tied; one followed by fatal gangrene, the other, although escaping gangrene, succumbing to pyæmia. Of the five remaining cases, two recover with little or no circulatory disturbance, three develop gangrene of the limb, of which two die, and one recovers after amputation. If we compare these with the cases of the same class in which simple ligation of the vein was done, and take the cases of gangrene alone into account, pyæmia being regarded as a preventible accident, it appears that where the vein alone was tied two out of five developed gangrene; where the artery was tied, either alone or simultaneously with the vein, four out of seven developed gangrene.[1] These numbers are not large

[1] NOTE.—In the discussion which followed the readiug of this paper two additional cases of occlusion of both artery and vein at the level of Poupart's ligament were reported. 1. By Dr. Sands, who stated that in Bellevue Hospital, nine years ago, a man was admitted under the care of one of his colleagues with a wound of the femoral artery and vein. The bleeding was arrested, but gangrene supervened, quickly terminating in death. 2. By Dr. Weir, who stated that during the war of the rebellion he had a case of gunshot wound at the edge of the groin, in which it was found afterwards that the missile had torn the vein across and occluded the artery; gangrene and death resulted.

The published records of the results of gunshot wounds of the fem-

enough to settle the question positively, but as far as they go they likewise discourage the practice of ligation of the common femoral artery as a prophylactic measure after wounds of the femoral vein high up, even in acute injuries.

The case of simultaneous ligation of the femoral artery and vein which I presented to this society one year ago[1] lacks in an important particular the requisites necessary to enable me to use it for purposes of comparison with the cases under consideration. On account of the conditions under which the ligations were made, I did not determine at the time of the operation the exact relative location of the vein wound, but my belief has been that it was below the point of entrance of the internal saphenous. Such being the fact, the relation of the case as regards the amplitude of collateral channels is quite different from those in which a ligature is applied at the level of Poupart's ligament. Whether, also, the arterial ligature involved the common femoral or the superficial femoral, must also be a matter of doubt. This, however, is worthy of note, in this connection, that during the first few weeks after patient began to go about, a considerable œdema of the leg and thigh manifested itself. This entirely disappeared within a few weeks

[1] Annals of Surgery. Vol. I. February. 1885. P. 167.

oral vein that came under surgical treatment during the war of the rebellion are not definite enough to be of much statistical value, nor, indeed, in any event, could the results of the military surgery of twenty years ago, in dealing with accidents of this character, shed much light on the results to be expected after such accidents in the private or hospital practice of to-day. The following, however, is given for what it is worth:

Two cases of gunshot wounds, involving both the femoral artery and vein, are recorded as having been treated, with death in each case.

Three cases of wounds of the femoral vein alone, all terminating fatally, one by pyæmia on sixteenth day, one on twenty-third day and one on eighth day, cause of death not given. These cases were treated by compression and styptics.

Of six cases, in which the external iliac artery was tied for wound of the femoral or profunda, or of these vessels and their accompanying veins, all were fatal.—*Med. and Surg. Hist. of the War of the Rebellion. Surgical Volume.* Part II., pp. 13 et seq.

and the man has ever since remained free from any disability from the injury. The case, nevertheless, will be found to have an important bearing as indicating a rational course of action to be pursued in the graver form of accident under consideration.

The extreme gravity of a wound of the femoral vein above the opening of the internal saphenous vein, in cases where there has been no pre-existing inguinal tumor, is seen in the fact that, of the twelve cases which have been analyzed, one half developed gangrene, all with fatal termination except in one case in which amputation was followed by recovery. This fatal gangrene is due to acute venous strangulation of the limb.

The immediate question which confronts the surgeon, therefore, is how to prevent this, or to diminish its intensity until a sufficiently free return of the venous blood is in some way provided for. Simultaneous ligation of the accompanying main arterial trunk has been shown by experience to increase the rate of mortality. Why this should be so it is not difficult to understand, for to diminish to an extreme degree the arterial supply to a part whose nutrition is already seriously compromised by general venous stasis, would certainly tend to precipitate and aggravate the threatened necrosis.

Braun (*loc. citat.*) founds his chief objection to the arterial ligation on that it deprives the arrested venous current of the *vis a tergo* which a full arterial current, bounding into the vessels of the limb, could exert, by means of which he believes that in some cases the valves of the chief collateral branches could be so far forced as to admit an immediate adequate collateral flow to take place through them.

If this theory were correct, an increase rather than a diminution of the arterial pressure in a limb would be an object to be sought in cases of the kind under consideration.

The physiology of the establishment of new collateral ways is, however, of quite a different character. It is by the dilatation and development of many previously minute and insignificant vessels that the new ways are established. Indeed, the experimental results of the anatomists referred to in the earlier part of this paper show without other observations that penetration of injected matter from the veins of the lower limb

into the pelvic veins, after ligation of the femoral, is not accomplished by overcoming definite valve-barriers and thus gaining access at once to wide paths, for if a thick and solidifiable injection material is used, no penetration is observed, but when a diffluent liquid, like turpentine colored with vermillion (Sappey and Nicaise), is used, then it flows with facility, for it now obtains entrance into a multitude of minute branches from the trunk into which it is first thrown, and then by multitudes of inosculating venules it is received and carried on until it is gathered together again in the larger veins that emerge within the pelvis, which finally convey it to the ascending vena cava. In the living subject the same phenomena are witnessed in every congested area where the rapid enlargement of previously minute and invisible vessels quickly supplies a part with a copious network of vessels now plainly discernible and capable of transmitting a greatly increased volume of blood. If the inundation of blood is more rapid and intense than can be provided for by this vascular dilatation, necrosis must take place, just as upon a larger scale it does in so large a proportion of the cases of sudden occlusion of the femoral vein at the level of Poupart's ligament. In cases of the accident in question the greater the arterial *vis a tergo*, the greater the danger of overwhelming and totally blocking the somewhat slowly enlarging collateral radicles. Where ample collateral paths already exist, it is unnecessary; where less immediately available collateral paths exist, it becomes an element of danger just in proportion to the absoluteness of their absence.

The idea, therefore, of obtaining any benefit in any case from the preservation of the full arterial pressure upon the circulation of a limb, whose chief vein has become occluded at its root, need never be entertained by the surgeon.

Having disposed of this consideration, the way is more clear to arrive at a conclusion as to what course is most likely to prevent the choking of the limb with blood, while the nutrition of the limb is still sufficiently provided for.

In the case of the lower limb I desire to suggest as a rational resource, and one least likely to entail new dangers, *ligation of the superficial femoral artery*. If this vessel be ligated, while the quantity of blood and the force of the cur-

rent through the limb will be very materially diminished, the amount of blood supplied to the limb will still be quite sufficient to provide for its nutrition.

Ligation of the superficial femoral artery is worthy of trial as a prophylactic measure in any case where sudden complete occlusion of the femoral vein has occurred at the root of the extremity. It is a rational means of accomplishing the immediate indication for lessening the amount of blood sent into the limb without endangering its nutrition. As an example in support of this practice my own case, above referred to, can now be cited. In this case the occlusion of the vein was at such a height that considerable œdema showed itself and persisted for some weeks after the patient began to walk about, although none had manifested itself while he was recumbent. The fortunate absence of serious disturbance of any kind in the limb during the early weeks after the ligature of the vein, and the comparatively speedy and lasting disappearance of the œdema are fairly attributable to the slight disturbance in the equilibrium of the arterial inflow and the venous output which the ligature of the superficial femoral secured. It is hardly necessary to state that in those cases in which a simultaneous wound of the common femoral artery and vein has occurred there is no choice of procedures but to ligate at the point of injury. In such cases it is especially important that the vein wound be closed, if possible, by a lateral suture or lateral clamp, so that complete occlusion of the vein may be avoided.

Recurring to the upper limb, since abundant experience has shown that the nutrition of that limb is not hazarded by a ligature applied to the axillary artery, ligation of that artery may unhesitatingly be performed as a prophylactic measure in cases in which diminution of the arterial supply to the limb seems desirable in consequence of extensive occlusion of the venous outlets at its root.

The final conclusions reached as the result of the foregoing discussion may be summarized in the following

RECAPITULATION:

1. Serious circulatory and nutritive disturbances are to be apprehended: *a*, in the upper extremity, when, in addition to

the occlusion of the main vein at its root, simultaneous occlusion of any considerable number of the lesser and collateral branches has also taken place; *b*, in the lower extremity, when the occlusion of the main vein at its root is sudden and complete, and has not been preceded by any conditions which might have occasioned a previous dilatation of collateral channels or the development of new ones.

2. The accidents of excessive œdema and of gangrene, when they occur, are due to the intense and active congestion of the limb, through the arteries, with blood for which there is no adequate outlet.

3. The development of collateral paths is not by the breaking down of valve-barriers at the entrance of large collateral trunks, but by the dilatation of a multitude of minute branchlets. To effect this an increased arterial *vis a tergo* is not required. Any increase in the normal blood pressure is attended with danger of overwhelming and fatally choking up the somewhat slowly enlarging collateral radicles.

4. The diminution of the amount of arterial blood which enters a limb whose chief venous outlets have become occluded down to an amount not greatly in excess of that which can readily find an outlet from it through paths still remaining, is the first great indication to be fulfilled in the treatment.

5. Whatever method is adopted to restrain the flooding of a limb with arterial blood, it must still permit the entrance of a supply sufficient for the nutrition of the limb. For this reason, in the lower limb, ligation of the common femoral is to be avoided, especially in the light of the disastrous results of such ligations already recorded.

6. Ligation of the axillary artery, in the upper extremity, and of the superficial femoral, in the lower, are safe expedients, and to be adopted as prophylactic measures, whenever occlusion of the venous outlets of a limb is so great as to hazard the integrity of the limb by reason of the circulatory stasis produced.